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7th INTERNATIONAL CONFERENCE ON MEANING AND KNOWLEDGE REPRESENTATION (4, 5 and 6 July, 2018)

Session 8 – 6th July 2018

How can one evaluate a conversational software agent framework?

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Overview

- Context – conversational agent space
- Linguistic approach
- Building blocks of a Linguistic CSA
- Drivers of LING-CSA
- Conceptual framework LING-CSA
- Implementation of LING-CSA
- How to evaluate LING-CSA?
- Evaluations and findings
- Evaluation – conclusions & recommendation

1 Conversational agents space

Figure 1 – Types of conversation
Source: FactionXYZ

Figure 2 – Hype cycle and myths
Source: FactionXYZ

2. Linguistic Approach

Conversational Software Agents (CSA)

- Challenges of NLU and meaning
- NL -> functional system
- Periñán-Pascual (2013):eligibility
- Communication-cognition
- Approach – unique framework, model/theory interaction, communicative
- Language levels, interface between syntax, semantic, and pragmatics
- Language Model: RRG and the clause

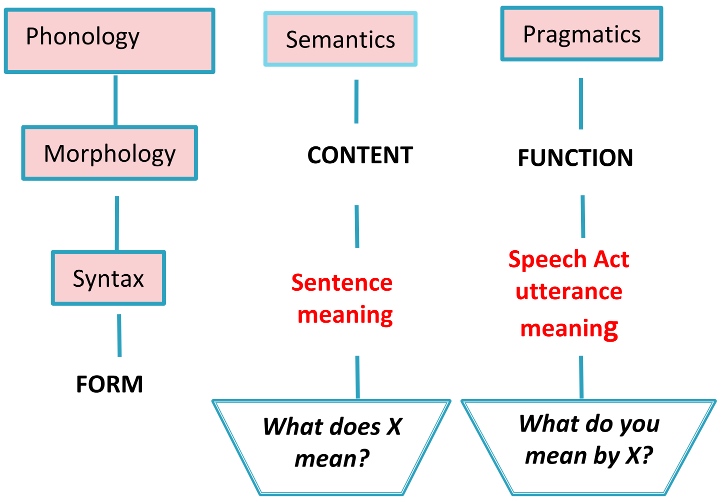


Figure 1: Language interfaces

- Simple sentences ->Linguistic act (Speech Act) – SA
- Understand the utterance
- Agent attributes
- (Utterance) Message from USER → AGENT
- Agent's belief – Knowledge representation (KR)
- Plan-based dialogue (response) Message AGENT → USER

3. Building blocks of a CSA

AGENT	+	INTELLIGENT DIMENSION (S)	=	INTELLIGENT AGENT

INTELLIGENT TAXONOMY Behavioural, Social, Ambient, Collective, Genetic, and **COGNITION**

COGNITION = BDI + Rational Interaction

CA = Interpretation + Dialogue Mgt + Response Generator

CSA = CA +RRG +SA + COGNITIVE + KB (Panesar,2017)

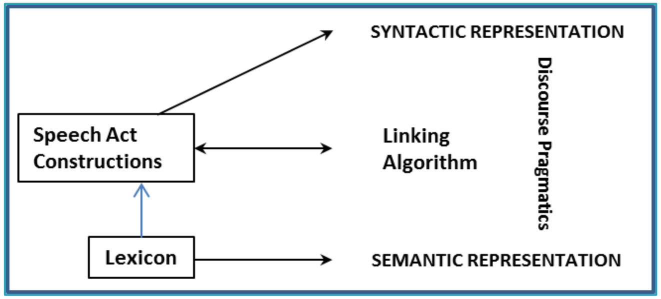


Figure 3– Reorganisation of RRG

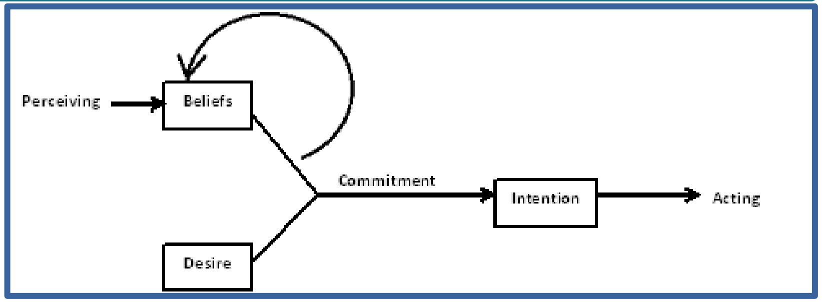


Figure 4– A BDI model of an intelligent agent (Allen, 1995)

4.Drivers of LING-CSA

- Investigate the *integration, intersection and interface* of the language, knowledge, and speech act constructions (SAC) based on a grammatical object (Nolan, 2014), and the sub-model of belief, desires and intention (BDI) (Rao and Georgeff, 1995) and dialogue management (DM) for natural language processing (NLP).
- A long-standing issue within NLP CSA systems is *refining the accuracy of the interpretation of meaning* to provide a realistic dialogue to support the human-to-computer communication.

5. Conceptual Framework: LING-CSA

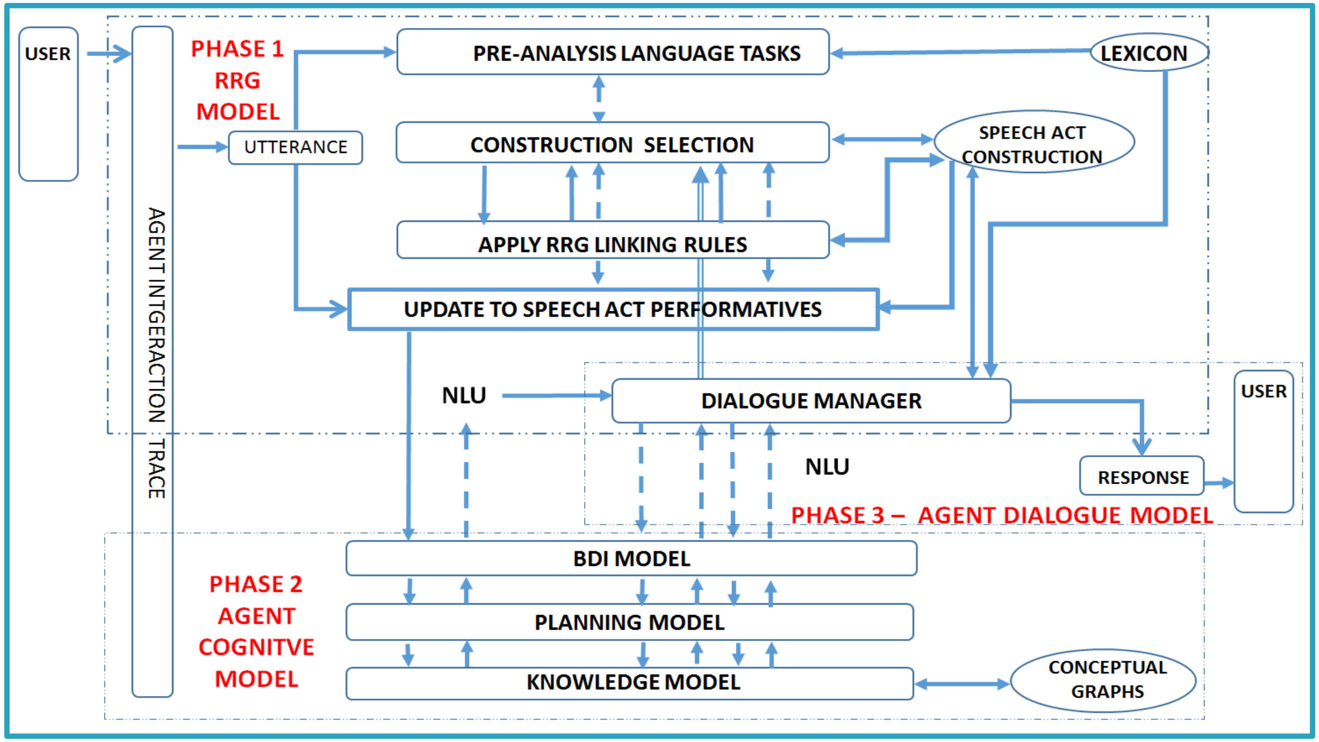


Figure 5- Conceptual framework of the Conversational Software Agent (Panesar, 2017)

PHASE 1 – Role and Reference Grammar (RRG) Language Model
PHASE 2 – Agent Cognitive Model interfaces with:
BDI Model, Planning Model, Knowledge Model
PHASE 3 – Agent Dialogue Model (Dialogue Mgnt > RRG Model

6. Phase 2 – Agent Cognitive Model Design Framework

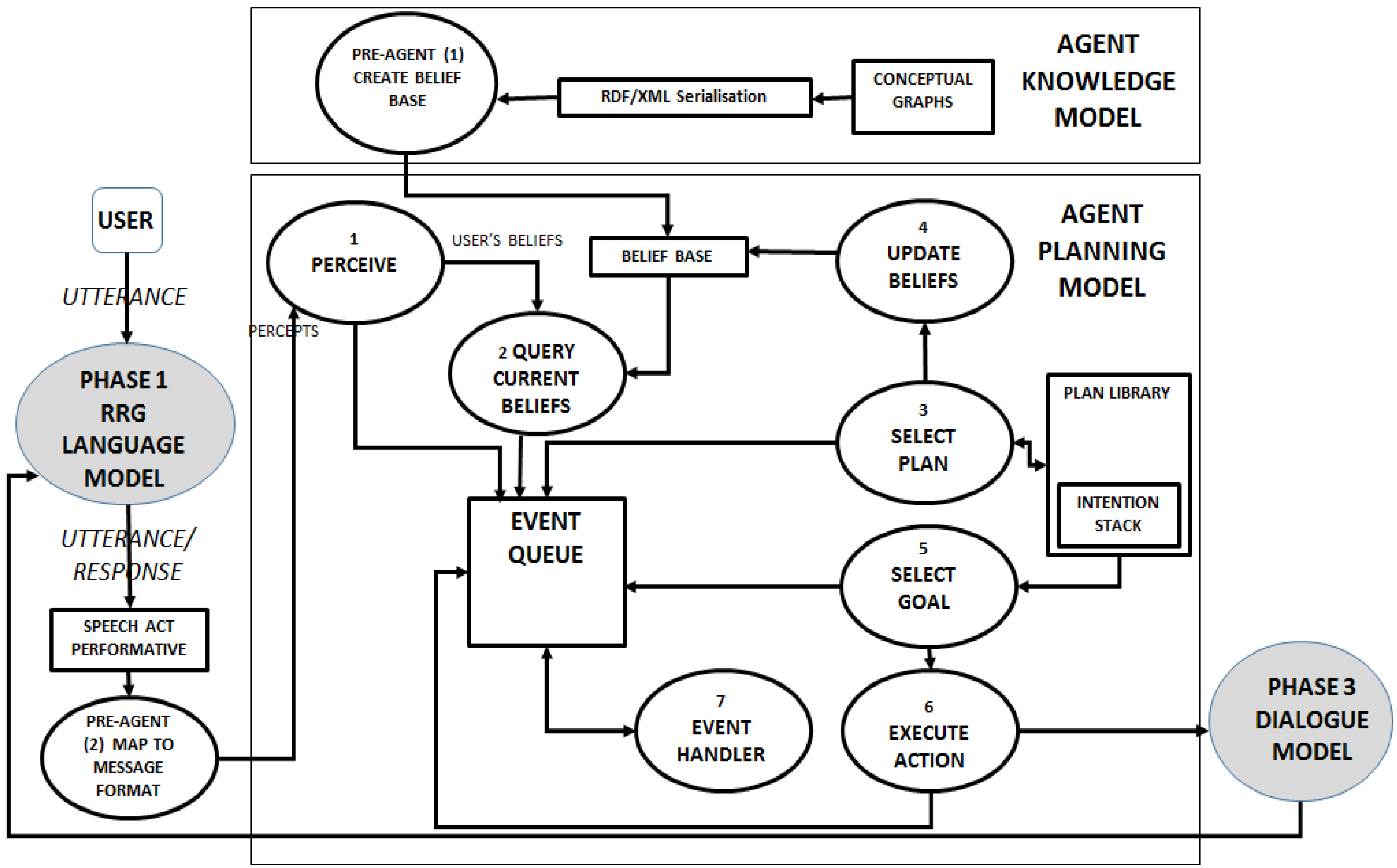


Figure 6 – The Agent Cognitive Model – Design Framework (Panesar, 2017)

7.How to evaluate LING-CSA?

- ISO 9241 concept of usability?
- Turing test?
- Define goals
  - Phase model based
  - Interfacing, intersection and integration
- Customised multi-approach assessment
- Testing strategy
  - Grammatical testing and NLP tasks
  - Software engineering
  - Knowledge representation
  - Agent practice and environment
  - RRG specific tests and goals of linguistic theory
- Evaluation criteria (goal-driven)

8. Evaluation criteria

Phase 1 – RRG Language Model

- Criteria 1– Could the system present a mapping of the syntactic representation to a semantic representation, for the utterance taking the form of a simple sentence?
- Criteria 2 – Could the system present an adequate explanation of the NLU of the utterance?
- Criteria 3 – Could the system demonstrate the SAC use in the manipulation of the utterance?
- Criteria 4 – Can the dialogue manager interface the language model?

Phase 2 and 3 – Agent Cognitive Model and Agent Dialogue Model

- Criteria 5 – Could the system demonstrate the agent BDI and knowledge representation?
- Criteria 6 – Could the system represent the user's BDI states?
- Criteria 7 – Could the system query the knowledge base for a fact (from the speech act performative)
- Criteria 8 – Could the system devise an appropriate plan based on the BDI states?
- Criteria 9 – Could the system generate a grammatically correct response in RRG based on the agent's knowledge?

9. Evaluation Phase 1 – RRG :LSC and LS

- RRG is a functional model. It views language as a communicative social action.
- Layered structure of the clause (LSC) = PREDICATE + ARGUMENT + NON-ARGUMENTS.
- Logical Structure (LS) – semantic meaning of the sentence.
- Lexicon - mental dictionary - lexical entries contain semantic features and constraints.
- It maps the syntax(structure): LSC ⟺ semantic (meaning): LS the actual form of the sentence using two different LINKING ALGORITHMNS.
- RRG parser (algorithm) checks the grammar (rules) of English. Specialised parser (CSA)
- RRG facilitates syntactic, semantic and information structure (FOCUS & TOPIC)

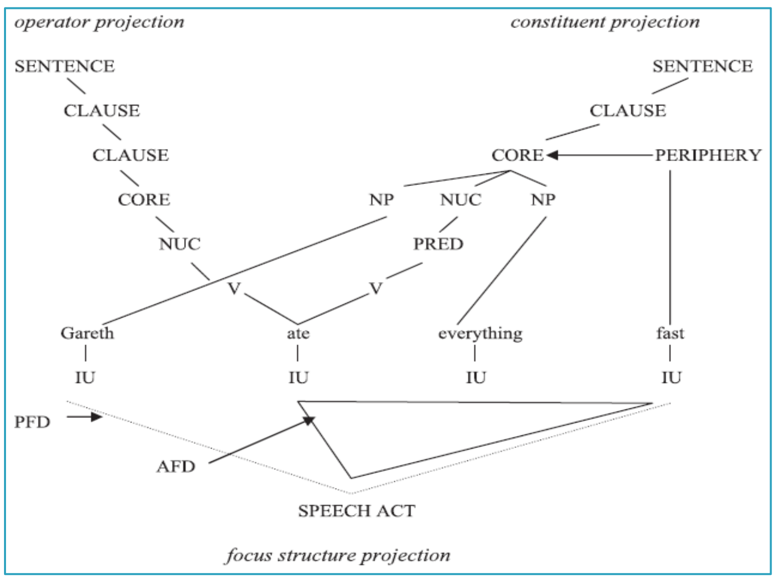


Figure 7 - An English sentence with three representations

RRG steps (Panesar, 2017)

Worked example

Gareth ate everything fast

(BNC ADY 1079) (Butler et al, 2009) –> Figure 5

SYNTACTIC:
SENTENCE (CLAUSE (<CORE> <NP> gareth (<NUC> (<PRED> <V> ate)) (<NP> (everything))) (PERIPHERY fast)

SEMANTIC:
[<IF> ASS <TNS> PST, do'(ACT:Gareth, (eat'(Gareth <NOM>, pizza <ACC>)])] & INGR consumed' (UND:pizza)]

10. Evaluation Phase 1 – RRG : Data sources – Lexicon, SA, & SAC

LEXICAL ENTRY	POS-TYPE	VERB TENSE/ ASPECT	DEF	P TYPE	NO	GR	CASE	ANIM	HUM	LOGICAL STRUCTURE (LS)
ate	VERB	PST	DEF+/-	3	SG	M/F	DNA	ANIM	HUM	<tns:pst <do'(x, [eat'(x, y)]) & BECOME consumed' (y) >>
eat	VERB	PRS/ FUT	DEF+/-	3	SG	M/F	DNA	ANIM	HUM	<tns:prs <do'(x, [eat'(x,y)]) & BECOME consumed'(y)] >> <tns:fut <do'(x, [eat'(x,y)]) & BECOME consumed'(y) >>
eating	VN	PROG	DEF+/-	3	SG	M/F	DNA	ANIM	HUM	<tns:prs <asp:prog <do'(x, [eat'(x, y)]) & BECOME consumed' (y)] >>>
is	VBE	DNA	DEF+	DNA	DNA	DNA	DNA	DNA	DNA	be'(x,[pred'])
hungry	ADJ	DNA	DNA	DNA	DNA	M/F	DNA	ANIM	HUM	DNA
restaurant	N	DNA	DEF+/-	DNA	SG/PL	DNA	DNA	DNA	DNA	DNA

Table 1 – Snapshot of the Lexicon (Panesar, 2017)

Speech (linguistic) Act (SA) Theory (Searle, 1969) – message types as in Figure 6

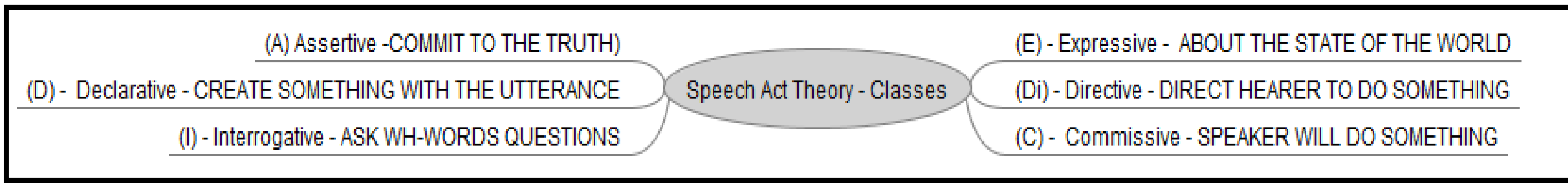


Figure 8– Speech Act message types

3 actions associated with an utterance include:

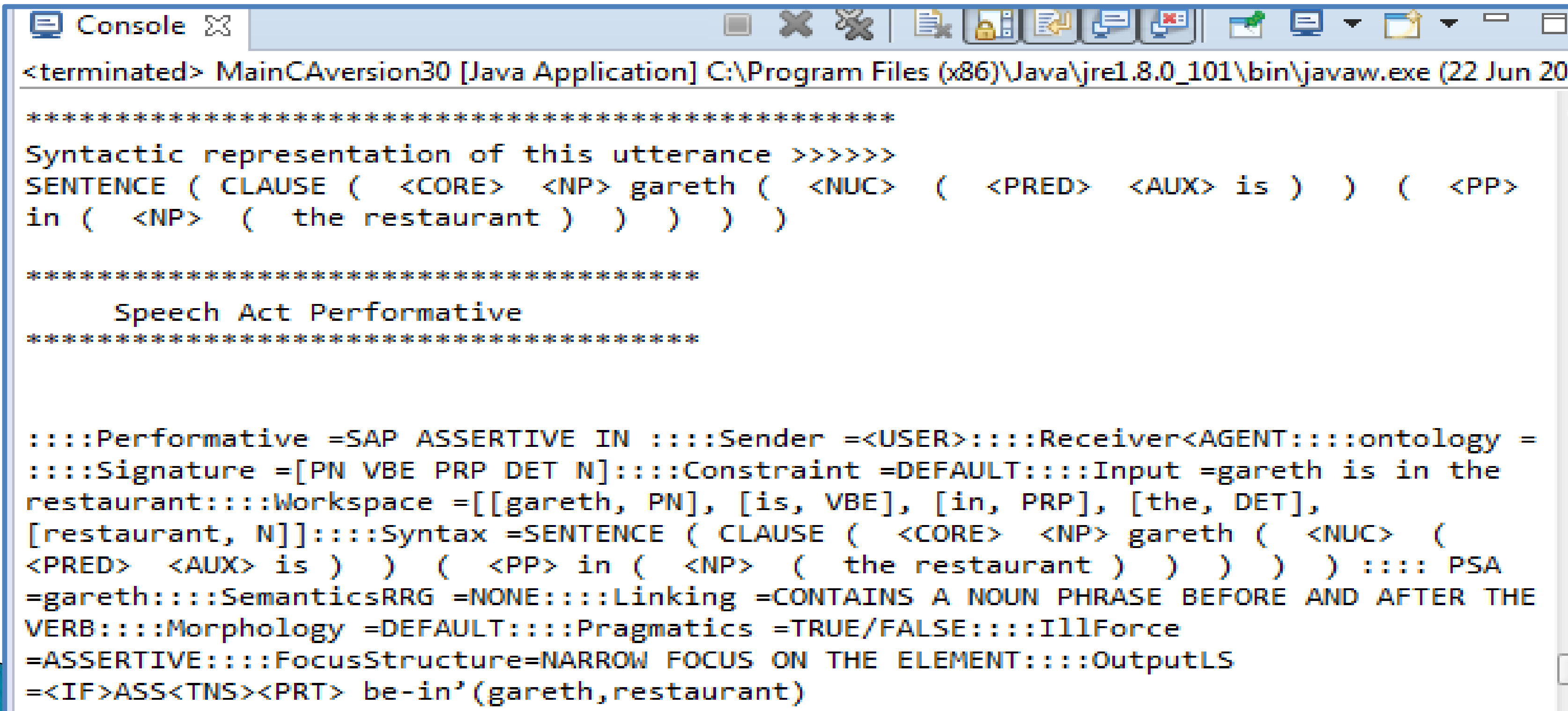
- Locution:
- Illocution: illocutionary act (speaker's intention) [SI] for A, Di and I message types
- Perlocution:

Figure 9 – Empty SAC (Speech Act Construction) (Panesar, 2017)

ASSERTIVE:ATE RRG [NP VERB NP], [PN VERB], [ADV PN VERB DET N], [PN VERB N ADJ], [PRP DET N PN VERB DET N], [PN VBE VERB N], [PN PRP DET N PRP DET N], [PRO VERB DET N], [PN VERB NP], [PN VERB DET N], [NP VERB QNT N], [DET N VERB DET N], [DET N VERB QNT N], [NP VERB (DET) (ADJ) N (ADJ)], [PN VERB DET N ADJ], [PN VERB (DET) ADV N ADJ], [PN VERB DET N PRP DET N], [PN, VERB, N, PRP, DET, N], [PN VERB N PRP DET N] RRG NONE RRG UTTINPUT RRG WKSPACE RRG DEFAULT ASSUMPTION (1ST NP = 'ACTOR") RRG NO PARTICULAR SPEC RRG NONE RRG CONTAINS A NOUN PHRASE BEFORE AND AFTER THE VERB RRG DEFAULT RRG TRUE/FALSE RRG ASSERTIVE RRG NARROW FOCUS ON THE ELEMENT RRG LOG STRUCTURE TO ADD

11. Evaluations (Phase 1 – RRG Model)

- Aim- assessment of Criteria 1 -4
- Each specific construal (either an utterance or response) –two steps.
  1. Find the matching SA construction of that specific predicating element. In Figure 2: ‘*is*’ and selected SAC of assertive.
  2. Select the matching signature pattern -> **[PN, VBE, PRP, DET, N]**
- Updates > SAC first and extended SAP (Panesar, 2017)



```
Console
<terminated> MainCAversion30 [Java Application] C:\Program Files (x86)\Java\jre1.8.0_101\bin\javaw.exe (22 Jun 201
*************************************************
Syntactic representation of this utterance >>>>>>
SENTENCE ( CLAUSE (  <CORE>  <NP> gareth (  <NUC>  (  <PRED>  <AUX> is )  )  (  <PP>
in (  <NP>  (  the restaurant )  )  )  )  )

**************************************
     Speech Act Performative
**************************************


::::Performative =SAP ASSERTIVE IN ::::Sender =<USER>::::Receiver<AGENT::::ontology =
::::Signature =[PN VBE PRP DET N]::::Constraint =DEFAULT::::Input =gareth is in the
restaurant::::Workspace =[[gareth, PN], [is, VBE], [in, PRP], [the, DET],
[restaurant, N]]::::Syntax =SENTENCE ( CLAUSE (  <CORE>  <NP> gareth (  <NUC>  (
<PRED>  <AUX> is )  )  (  <PP> in (  <NP>  (  the restaurant )  )  )  )  ) :::: PSA
=gareth::::SemanticsRRG =NONE::::Linking =CONTAINS A NOUN PHRASE BEFORE AND AFTER THE
VERB::::Morphology =DEFAULT::::Pragmatics =TRUE/FALSE::::IllForce
=ASSERTIVE::::FocusStructure=NARROW FOCUS ON THE ELEMENT::::OutputLS
=<IF>ASS<TNS><PRT> be-in'(gareth,restaurant)
```

Figure 10 – Snapshot output of LING-CSA (Panesar, 2017)

12. Phase 1 – RRG & Speech Act Performative

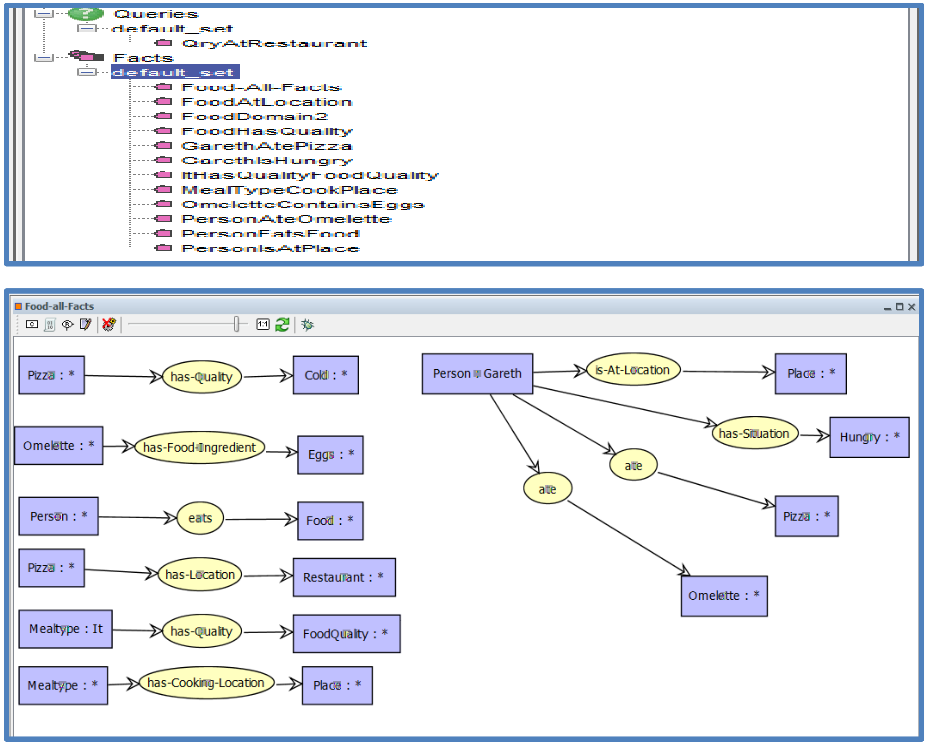
Based on the SAC with four additional attributes. Input to Phase 2-ACM

PERFORMATIVE: <ASSERTIVE:ATE>
:SENDER <USER>
:RECEIVER <AGENT-1>
:ONTOLOGY <FoodAndCookKB>
:CONTENT <do'(Gareth, (eat'(Gareth, pizza)])] & INGR consumed' (pizza)] everything>
SIGNATURE: [PN V NP ADJ] CONSTRAINT: Default
INPUT: Gareth ate everything fast
WORKSPACE: (Gareth, PN), (ate, VERB), (everything N), (fast, ADJ)
SEMANTICS: Contains a noun phase before and after the verb
CONSTRUCTION BODY SYNTAX: SENTENCE (CLAUSE (<CORE> <NP> gareth (<NUC> (<PRED> <V> ate)) (<NP> (everything))) (PERIPHERY fast) PSA: gareth SEMANTICS Linking: MORPHOLOGY:Default PRAGMATICS Illocutionary force: ASSERTIVE Focus structure: narrow focus on the element
OUTPUT [LS]: [<IF> ASS <TNS> PST, do'(ACT:Gareth, (eat'(Gareth <NOM>, pizza <ACC>)])] & INGR consumed' (UND:pizza)]

Table 2-Speech Act Construction Performative "ate" used as a message to the Agent Environment (Panesar, 2017)

13. Phase 2 – Agent Cognitive Model & Knowledge Model (Panesar, 2017)

SHARED and INDIVIDUAL BELIEFS cognitively → mental knowledge.



- **Conceptual graphs** (CGs) (Sowa,1986), Vocabulary, First order logic (FOL) created in COGUI as in Figure 7 and 8
- **Serialised** into RDF/XML (W3C SW), mapped to RDF Triple Stores – forms the agent's belief base – 446 lines (Table 3)
- KB ready for querying to check truth of the agent's beliefs
- Key Performance Indicators – representational and inferential adequacy

Figure 11 & 12– COGUI– Original KB of facts – graphically

Table 3 – Extract of a RDF triple Stores KB

No	Subject	Predicate	Object
1	http://www.lirmm.fr/cogui#ct_ad452f18-e654-4ae6-b3a1-b7320616283b	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.w3.org/2000/01/rdf-schema#Class
2	http://www.lirmm.fr/cogui#ct_fdc6d7d0-1314-4fb7-8428-51e122953250	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.w3.org/2000/01/rdf-schema#Class

14. Lexical Bridging Solution (Panesar,2017)

Reduce this semantic gap, by "building a lexical bridge (LB)" between the NL semantic and ontology semantics, with an aim to capture more of the meaning, by attempting to 'lexicalize the ontology'.

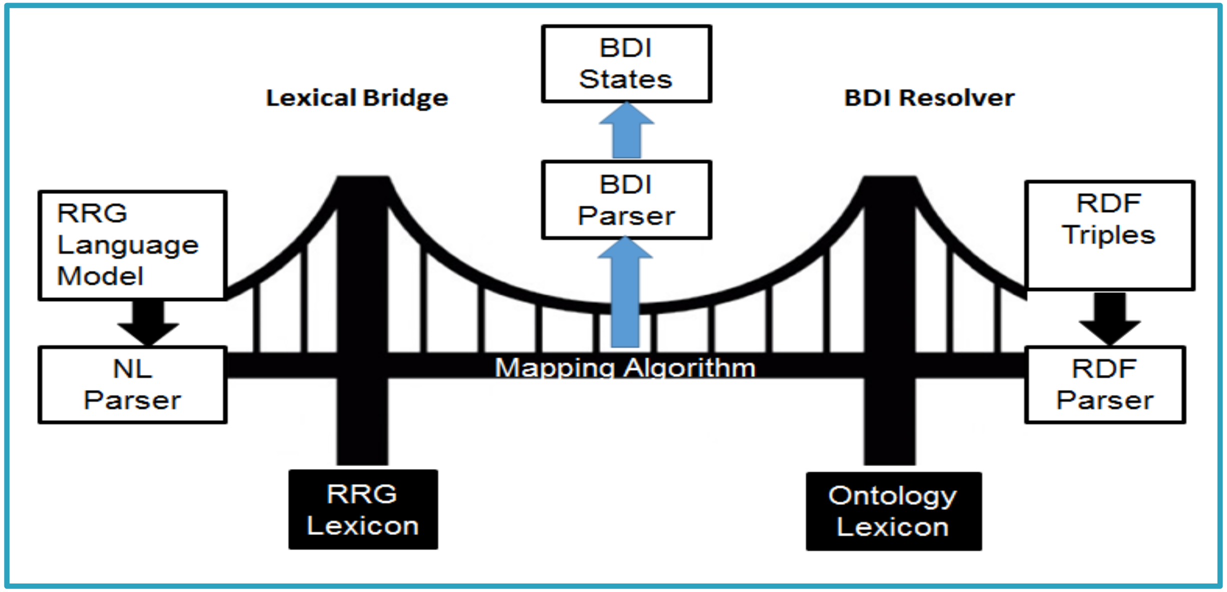


Figure 13 - Lexical Bridge for the CSA's belief base + BDI Parser to resolve the agent's BDI states

15. Evaluations, Findings, and Recommendations

Implementation outcomes :

- Proof-of-concept achieved;
- Dialogue Manager is common to Phase 1 and Phase 3

Findings

- RRG is fit for purpose ->linguistic engine for the CSA;
- RRG explains, describes linguistic phenomena; facilitates language processing and knowledge of language -> computationally adequate (Panesar, 2017)

Phase 1 – RRG Model Improvements:

1. All pronoun resolutions (E.g. 'Your', 'she', it' etc.)
2. Application of the propositional stranding rules
3. Complex sentences (extension of the RRG linking system)
4. Multi-lingual (additional lexicons) such as Spanish
5. Other SA classes such as emotive and commissives E.g analyse tweets
6. Include superlative adjectives/adverbs in the RRG Lexicon (E.g. 'spicier')
7. Invoke WordNet API for synonymous entries to the RRG Lexicon – ⇧value

Phase 2 Agent Cognitive Model working – 70% achieved Dialogue mgnt

Technical Challenge – Querying a natural language (NL) text against a knowledge representation (KR) of RDF triples poses a significant semantic gap

Conceptual solution (lexical bridge, BDI parser and RDF parser) (Panesar, 2017)

Single agent to multi-agent environment – an extended design framework

Content creation – via machine learning algorithms

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Thank you for listening!